Vegetation changes during the second part of the Wurmian glaciation in lowland and mountain regions: refugia and fire history

Thesis of Doctoral (PhD) dissertation

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1 Introduction, aims

The motivation in the background of my doctoral research was the scarcity of plant macrofossil studies that would cover the Last Glacial Maximum and the Late Pleniglacial intervals (24000–14600 cal yr BP, TZEDAKIS et al. 2013) in the Carpathian Region. The available pollen and charcoal studies from Eastern and Southern Europe imply sparsely wooded landscape during this period (e.g. WILLIS et al. 2000; WILLIS & VAN ANDEL 2004; TANTAU et al. 2006; TONKOV et al. 2011; GAŁKA et al. 2013; TZEDAKIS et al. 2013). On the other hand, plant macrofossil studies from this period are scarce, therefore there is little evidence on the local presence of a species soon after the LGM that would confirm the refugial role of the Carpathians during the Last Glacial Maximum. Several studies investigated the changes of the vegetation and environment during the LPG in Hungary (e.g. BORSY 1989; CSERNY 2002; CSINÁDY 1960; JAKAB et al. 2005; JAKAB et al. 2009; MAGYARI et al. 1999; MAGYARI et al. 2000; MEDZIHRADSZKY & BAJZÁTH 1998; RUDNER & SÜMEGI 2001; SÜMEGI & GULYÁS 2004; SÜMEGI et al. 2013, WILLIS et al. 1995) that were mainly based on pollen and/or plant macrofossil analyses.

Pollen based quantitative climate reconstructions provide the regional aspect of the vegetation and climate change (SEPPÄ et al. 2004; WHITMORE et al. 2005). Due to their low taxonomic resolution these reconstructions can only carefully be applied in treeless environments (AARNES et al. 2012). On the other hand, plant macrofossils provide identification on species level, which would imply their local presence, as macrophytes are widely recognized as climate indicators due to their ability to react faster to climate change (IVERSEN 1954). Plant macrofossil studies are useful for paleoclimate and vegetation reconstructions because the environmental tolearance of living species that cahracterised the last glacial landscape are well known (VÄLIRANTA et al. 2015). The characteristic features of plant macrofossils helped in my doctoral research to investigate past local vegetation changes in lowlands and mountains, to reveal mire development phases, to detect local fire histories, to explore the effect of the Heinrich-1 cooling event on the vegetation (17500–16000 cal yr BP) and to reveal past treeline and timberline changes at high altitudes, species compositional changes in the treeline ecotone and the impact of human presence in the alpine region. The investigation of the Holocene treeline and timberline changes in the South Carpathians is highly significant due to the lack of these studies in the Romanian Carpathians, this topic

became more highlighted only recent past, when detailed study was made in the Rodna Mts, these results are also well comperable to the Alps, where treeline and timberline changes are extensively documented.

2 Study area and sampling

My doctoral research focused on three different study areas. I studied the deposits of a volcaninc lake, Lake St. Anne (950 m asl.) in the Ciomadul Mts of the Eastern Carpathians, a small mire from the Érmellék region called Kokad (112 m asl.) and the high-altitude lakes of the Retezat Mts of the South Carpathians: Lake Brazi, Lake Gales, Lake Lia and Lake Bucura (from 1740 m to 2040 m a.s.l.). The sediment core of Kokad was taken in 2008, while the high-altitude lakes were sampled during 2007 and 2008. The coring of Lake St. Anne took place in 2010. The main focus of the selected cores was to cover the Late Pleniglacial and Lateglacial period by studying the vegetation changes during these intervals.

3 Methods

During the laboratory preparation of the samples, first heating with destillated water or 10% NaOH solution was applied, which was then followed by wet-sieving through 250µm and 180µm meshes. The plant macrofossil remains were studied under stereomicroscope with the aid of identification keys and the reference collection of the MTA-MTM-ELTE Research Group for Paleontology. Sediment components together with other remains (needles, seeds) were determined, as well as moss leaves and stems, monocotyledon remains, macrocharcoal were detected by using the methods of JAKAB et al. (2004). For the macrocharcoal analysis, 1cm^3 samples were taken from the core continuously and prepared by following the methodology of GENRIES et al. (2012). Under the camera equipped binocular microscope not only the number of the macrocharcoal particles were detected, but their surface area too. The results were interpreted by the CharAnalysis software (HIGUERA et al. 2009). The plant macrofossil and macrocharcoal results were interpreted together with the results of the radiocarbon measurement, the loss-on-ignition, the geochemical elements, the grain-size distribution and the pollen results.

4 Theses

1. On the basis of the plant macrofossil analysis of Lake St Anne, I proved that coniferous species were the first to appear on the crater slope during the Late Pleniglacial warming, pine (*Pinus* sp.) around 16200 cal yr BP, then spruce (*Picea abies*) around 15900 cal yr BP. The early colonisation of the conifers coincided well with the pollen results, which revealed boreal forest expansion with the mixing of *Betula-Pinus-Larix-Picea* individuals.
2. I proved that the Younger Dryas cooling is presented by a short-term decrease int he organic content of Lake St Anne, in parallel with frenquent spruce (*Picea abies*) and birch (*Betula* sp.) remains between 13000 and 12500 cal yr BP, suggesting that they became more frequent around the lake, while Poaceae and *Artemisia* became dominant regionally at the same time.
3. On the basis of the plant macrofossil analysis of Kokad, I proved that mesotrophic conditions occurred with brown mosses during the Late Pleniglacial, when reed (*Phragmites australis*) and bulrush (*Typha angustifolia és T. latifolia*) were present in the mosaic-like shallow water-level conditions. The apparance of bulrush imply warm, >12–15,7°C July mean temperatures soon after the LGM in the Érmellék region (VINCZE et al. 2019).
4. I proved that the timing of biogenic carbonate formation at Kokad mire is one of the earliest detected in the Great Hungarian Plain (GHP) at 16170 cal yr BP. The major period of the biogenic carbonate formation (from 15200 cal yr BP) preceded other similar events identified in the GHP substantially, by ~3000 years (VINCZE et al. 2019).
5. By reconstructing the local fire history at Kokad mire, I proved that local fire history significantly differs from the regional fire history: Kokad had low fire activity between 15000 and 4000 cal yr BP, either due to the reed-dominated vegetation around the mire during the late glacial, or due to the frequency of reed-swamp areas in the Érmellék region that was likely is characterised by high groundwater table durig the lateglacial and Early Holocene.
6. I demonstrated that both the treeline and the timberline reached their maximum elevation between 8000 és 3200 cal yr BP in the Retezat Mts, and their altitudinal fluctuation was 100–150 m (VINCZE et al. 2017). On the southern slope of the Retezat, Dwarf pine (*Pinus mugo*) dominated the vegetation at the level of 2040 m a.s.l. until the mid-Holocene, while Swiss stone pine (*P. cembra*) and spruce (*Picea abies*) developed a closed forest at 1910 m asl. (VINCZE et al. 2017).
7. By comparing the local fire history of the Retezat Mts (southern and northern slopes), I have proved that the fire activity on the southern slope agrees well with the regionally

reconstructed Early Holocene high fire activity, although the human impact only related to moderate biomass burning until 1300 cal yr BP and became more intensive during the last 1000 years.

8. I have recognized by comparing the plant macrofossil and pollen results that human impact in the Retezat Mts. probably became significant during the Bronze Age, from 4200 cal yr BP, and it significantly changed the species composition and the extension of the treeline ecotone zone (VINCZE et al. 2017). On the southern slope, the alpine meadows dominated by *Nardus stricta* and *Festuca* spp. today developed under continuous grazing over the past 2600–2200 years (VINCZE et al. 2017).

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